WATERBURY

Broken Stone Roads Near Polo, Illinois

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BROKEN STONE ROADS NEAR POLO, ILLINOIS

BY

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

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ENTITLED Broken Stone Roads near Polo, Illinois

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Civil Engineering

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Broken Stone Roads near Polo, Illinois.

It is proposed to describe the broken stone roads near the writer's home and incidentally to discuss some of the principles of road construction.

Location.— Polo is a town of about 2,000 inhabitants, situated in the north central part of the state, in Buffalo township, Ogle county. The surrounding country is rolling prairie and the soil is a rich black loam, well adapted to farming purposes but upon which it is somewhat difficult to construct good roads. Limestone is abundant in this locality.

History.— The first attempt to build stone roads was made by the city of Polo about twenty-five years ago, at which time the city began to cover the principal streets with a layer of lime-stone

broken by hand. This method of construction was continued until about ten years ago, when the city and township together purchased a stone crusher and a horse road-roller. Since that time the streets which have been improved have been covered with macadam. Polo has about seventeen miles of streets of which about eleven miles are covered with stone.

When the crusher was first installed the township confined its work to patches of macadam to fill up mud holes. In 1896 the township began its first systematic work of road construction, at which time about one mile was built west of Polo. The next year the township sold its share of the crusher to the city, and purchased a new one. In 1897 about one mile of road was constructed east of Polo, and in 1898 about one mile extending into the country to the South-

east. The next year a little work was done in various places. In 1900 two miles of macadam was built, extending south to the township line to connect with the stone road being built by Woosung township. During the past year (1901) another two miles was constructed northwest of Pols, from the end of the mile built in 1896.

Woosung township, which adjoins Buffalo on the south, did not begin the construction of broken stone roads until 1899; but during that year built 1¼ miles and in 1900, 3¾ miles.

Underdrainage.—In neither Buffalo nor Woosung township has any attention been paid to underdrainage, since the ground is rolling, with no stretches that are precisely level, and it is thought that underdrainage will take care of itself. It would seem, however, that in many cases considerable advantage could

be gained by the proper use of tile. For the best results in any kind of a road, it is essential that the stratum of soil near the surface and beneath the track should have thorough underdrainage, besides providing for the surface drainage by means of side ditches or gutters. Where the ground is rolling the surface stratum will in time drain out, but this action can be greatly accelerated by the use of underdrains placed below the frost line. Such drainage tends to keep the foundation of a stone road dry and solid, and also brings the earth track into use sooner where two tracks are provided.

The number of tile drains to be used and their position will depend upon the soil and the character of the surface. Probably the best method is to place a line of tile at each side of the road, beneath the gutters at a suffic-

ient depth to prevent injury by frost. Where the surface is quite rolling one line might be sufficient. If the land on one side of the road is higher than on the other, if only one line of tile is used, it should be placed on the high side to intercept the underflow.

Preparation of Subgrade. - In Buffalo township considerable care has been exercised in the preparation of the subgrade. For the work which has been done during the last three or four years, the township has engaged the city engineer of Polo to determine the grades and set the stakes. The tops of the hills have been cut down, the low places filled up, and the culverts widened. The grading has been done principally with wheeled scrapers. After all the filling necessary, or all that could be afforded, had been completed, the crown of the surface is formed with a road

grader, and then rolled.

The first roads were made by placing the macadam directly on the surface without preparing any trench, and then throwing a little dirt against the edges with a grader to prevent the spreading of the stone. In the later construction the stone has generally been placed in a trench excavated for the purpose with a grader. The rule now is to place the macadam in a trench wherever the ground is rolling, but not in a trench where the surface is nearly level. The reason for this difference is that where the surface is rolling the water running off the stone roadway will tend to wash away the dirt at the sides, if the trench construction is not used, which would leave the stone in a dike whose edges are likely to ravel. Moreover, if the roadway is narrow, and the surface construction is used, teams will have difficulty in passing each other

and also in getting from the dirt track to the stone road. Where the road is level, a trench is not used, because it would bring the stone surface nearly level with the dirt track, and therefore it would not drain well. Where the grade is very steep the macadam is placed on the surface without a trench and with sufficient crown to make the slope from the center to the side exceed the longitudinal grade of the road, for the purpose of causing the water to flow to the sides instead of down the wheel tracks where it will wash away the stone and cause ruts.

Apparently the trench construction is the better for level roads, provided proper care is taken in underdraining. However, those roads on which the macadam was placed on the surface have for the most part, especially on level ground, given very good satisfaction; and as the trench increases the cost of the

road, it may sometimes be advisable not to use a trench, if the cheapest road that will do is desired.

Grooving township has not given much attention to the subgrade, but has merely crowned the surface a little, placed the stone on top, and graded up against the edges of the stone.

Stone.-- The stone used for road purposes around Polo is a yellow limestone which crushes easily. The stone varies somewhat according to the quarry from which it is obtained and its location in the quarry. The stone taken from the upper layers is very soft when taken out and will sometimes almost fall to pieces; but this same stone when exposed to the air for a few months becomes quite hard and will ring when struck with a hammer. It is advantageous to crush this stone and then allow it to weather until needed. The stone taken from the layers deeper in the quarry is hard.

er as the depth increases and changes from yellow to blue limestone. This stone is much harder when first quarried than that taken from the upper layers, but does not increase in hardness as much as the softer material.

Stone best adapted to road purposes should be hard and tough that it may not crush easily or wear into dust under the action of traffic. It should also have good binding properties, and should not disintegrate under the action of frost or the weather. The stone at Polo is not hard, but it does not wear away rapidly under the traffic to which it is subjected, and has given very good satisfaction. The binding quality depends upon the irregularity in shape of the pieces and upon cementing property; and both of these requirements are quite well satisfied by Polo limestone. It seems not to materially deteriorate by weathering.

Theory of Broken Stone Roads. —

Macadam is composed of a layer of angular pieces of broken stone whose interstices are filled with a finer material called binder. The coarse material has no specific name; but, following the analogy of the nomenclature of concrete, it may be called the aggregate. The binder may be screenings of the same material as the aggregate, or it may be sand or gravel. Asphalt and tar are occasionally used in place of the fine material.

The purpose of macadam in common with all pavements is to form a smooth surface which shall make easy traction; to form a tight roof which shall keep the foundation dry; and to provide a stratum thick enough to distribute the pressure so that the soil can carry it. To produce imperviousness it is necessary that the voids in the macadam, at least at the surface, be filled. Upon first thought it would seem that the best method of doing this would be

to use unscreened stone, since a mixture composed of all sizes of material will contain the minimum number of voids. If macadam was of the same nature as concrete, this method would produce the desired results; but on account of the difference between the two, deductions for the one do not apply to the other. Macadam is rolled before the binder is added, to wedge the pieces of stone together and bind the whole into a compact mass. The voids must not at the beginning be filled with fine material, as it will prevent the compacting. Therefore, to properly construct a macadam road, a layer of screened stone should be placed and thoroughly rolled, and then the voids should be filled with a binder applied on top and worked down by rolling and sprinkling.

Laying the stone. — In Buffalo township the bottom course is constructed by depositing large stones and breaking them by hand. Over

this is placed a layer of coarse crushed stone; then finer stone and finally the top dressing. It is not thought that this method is better than to use crushed stone entirely, but it is cheaper; and as the top layer of crushed stone is quite thick, it is not expected that it will wear through. It is also thought that the lower part of the stone never becomes so compact but that it will act as a drain. It is undoubtedly true that the lower portion of the stone will never become entirely compact, unless rolling rolling is begun as the stone is laid; but the road should not be designed with the intention that the lower course will be a drain, because water is not expected to pass through the surface, for if the ground below is likely to be satidrated the water should be removed by the use of underdrains.

The thickness of stone necessary for a road should be sufficient

to distribute the concentrated pressure of the wheel over an area of soil so large that the load will be carried without indenting the surface. The thickness will depend upon the supporting power of the soil and the maximum weight on the wheel.

It is not possible to accurately compute this thickness; but the following method of investigation may be of a little interest in this connection. The concentrated pressure of the wheel on the top of the road will be transmitted to the soil in diverging lines; and it may be assumed that the area of the soil which supports the load is the base of a cone the apex of which is the point in contact with the wheel. The height of the cone is equal to the thickness of the broken stone, which for convenience call t. The sides of the cone make an angle with the vertical of about 45°. The area of the base of the cone will then be πt^2. Let W represent the load in

pounds on one wheel; and let ϕ represent the safe bearing power of the soil, in pounds per square inch.

Then

$$W = \pi t^2 \phi; \text{ or } t = \sqrt{\frac{W}{\pi \phi}}$$

Assume the maximum value of W to be 2,000 lbs. and ϕ to be 14 lb. per sq. in. (1 ton per sq. ft.). Substituting these values in the above equation gives $t = 6.75$ inches. According to this computation, a road 6.75 inches thick would be safe for the above soil and traffic. It is certainly true that the supporting power of a stone road varies approximately as the square of the thickness.

The width and depth of stone laid in Buffalo township has been different in different years. In 1900 it was laid with a width of ten feet, a depth of ten inches at the center and six inches at the edges. In 1901 the width was nine feet, the depth at the center fourteen inches and at the edge ten inches. The tendency has been

been to increase the thickness of the stone. It would seem that fourteen inches was ample for the roads in question, and that for ordinary country traffic a less depth would be sufficient, if the foundation is well drained and if the roads were otherwise well designed.

The above width of roadway answers the purpose fairly well for country districts where the width sufficient for two tracks cannot be afforded. However, it is well where there is much traffic to have the roadway wide enough to allow teams to pass without getting off the hard road. This prevents dirt from being brought on the stone from the dirt track. The greater width also allows traffic to spread over the road so that wheel ruts will not form as rapidly as on a narrow roadway.

Top Dressing.- The top dressing used in both Buffalo and Wooster townships consist of the finest screenings from the crusher. If too much of this is not used, it gives good results.

The fine screenings and dust from yellow limestone consist, to a large extent, of clay. If only enough of this to fill the voids is used, it makes a very good binder and helps to produce an impervious surface. If too much is used, it forms a layer upon the surface which makes dust when dry and sloppy mud when wet.

Picking up.- The top dressing is picked up by the wheels, if mud is brought on newly made stone road. A bad case occured when the City of Polo macadamized East Dixon street. The work was done late in the fall of 1896; and the day after the road was completed about six inches of soft snow fell before the ground was frozen, causing soft mud to be formed on the dirt streets adjacent. This mud picked up on wheels and was carried on the stone road. The mud and the snow picked up the top dressing until the weight of stone and mud caused the mixture to fall off in chunks. The next wheel

striking the chunk knocked off, some more and the surface of the street soon became like the waves of the sea, with waves from ten to fifteen feet apart. This was remedied the following spring by removing the humps with picks, and discarding the material so removed. Since then this piece of macadam has been entirely satisfactory. A few other places have acted in the same manner, but not to as marked an extent. In the worst cases not only was the very fine dust picked up, but also the medium sized pieces of stone, thus causing the road to be very bad for the time being and also causing much complaint from the public and from the adjacent property owners who firmly believed that the condition of the surface could not be remedied without the entire reconstruction of the road. This experience has taught the necessity of giving attention to the amount and character

of the top dressing used and the importance of preventing dirt from being carried on to the road. As an aid to the prevention of carrying mud on to a newly made stone road, Buffalo township now leaves a short piece composed of very coarse stone without top dressing, at the end of the stone where it joins the earth section.

Rolling.- In both Buffalo and Wooster townships, no rolling is done until all of the coarse stone is laid, when the road is rolled with a six-ton horse-roller. The width of the roller is six feet, which makes a pressure of only one ton per foot of width. This pressure is entirely inadequate to compact the surface sufficiently to resist traffic, since wheels may exert a pressure of half a ton on a width of 1½ to 2 inches. Consequently the roller can merely begin the compacting process which must be completed by the traffic. Moreover, to secure a

compact mass of macadam, a layer of about three inches of stone should be placed upon the road and rolled, and then another layer, which in turn is rolled, and so on until the required thickness is obtained. Thin layers should be employed because a pressure exerted upon a point on the surface spreads over an increasing area as it is transmitted downward, so no amount of rolling upon the surface can exert any considerable pressure on the lower layers of the stone. However, such rolling adds considerably to the cost of the road, and for that reason is not used near Polo.

Watering: Some of the macadam constructed within the city limits is watered with a street sprinkler after the top dressing is in place and while the rolling is in progress. This washes the binder into the voids and materially helps to solidify the structure. None of the work done

outside of the city is watered except by rains because of the expense.

Cost. In Buffalo township the cost of the two miles of road constructed in 1900 was $1,700.00 per mile, including grading. Of this two miles, one and one half miles was done by contract, the price, exclusive of the preparation of the subgrade, being $2,180 for all, or $1,453.33 per mile. Of the work done by the township $642.00 was donated, which includes nearly the entire cost of grading. As before stated, the width of the road built in 1900 was ten feet, the depth of stone ten inches at the center and six inches at the edges. The average length of haul was one and one half miles, and the cost of hauling was 20 cents per yard for the entire distance, or 13⅓ cents per cubic yard per mile, or about 10 cents per ton mile. The average cost of quarrying and crushing was 40 cents per cubic yard.

In 1901 the total cost of building

two miles of road by day labor, was $1,800.00 per mile. The width of this road was nine feet, the depth at the center being fourteen inches and at the edges ten inches. The average haul was three miles, which accounts for the difference in cost of the roads built in 1900 and those built in 1901.

In Woosung township all of the stone roads have been built by contract. Those built in 1899 cost $4.20 per rod, or $1,344.00 per mile; and those built in 1900 $4.40 per rod, or $1,408 per mile. There was very little grading, most of it being the throwing up of a little dirt along the edge of the stone, which cost 10 cents per rod. The width of the roadway is ten feet, the depth at the center ten inches and at the edges six inches. The average haul was one and one quarter miles. The cost of quarrying and crushing was 25 to 30 cents per cubic yard.

Road Taxes.- In Buffalo township the road tax is $1.00 on each $100.00 of valuation, for general road and

bridge purposes including hard roads. The law in Illinois allows a levy of $0.60 for a general road and bridge tax, and also an extra special tax of $1.00 for hard roads, but in Buffalo township they levy only $1.00 for both purposes.

In Wyoming township there is a special hard road tax of $1.00 all of which is used for hard roads, and also a general road tax of $0.60.

By this method of taxation, the cost of the roads is distributed equally over the township without regard to the location of the improvement. If all the roads in the township could be macadamized within a short time, this method would be equitable; but it must necessarily be some time before all of the roads can be improved. On this account, the commissioners of Buffalo township prefer some method of assessment whereby the cost is proportional to the benefit, but have not adopted it. This is undoubtedly the right principle; but the practice has not caused much complaint, since most of the farmers are

too anxious to secure hard roads to throw any obstacles in the way of the improvement. Nor is there any complaint that the benefits derived from the hard roads are not well worth the investment.

Maintenance.- In neither Buffalo or Brooklyn township is much attention given to maintenance. After the road is once finished, it is allowed to remain untouched until complaints are made; when the surface is repaired by adding crushed stone.

Results.- The results of the roads above described have been very satisfactory. They do, of course, get muddy, but not like dirt roads. The mud is merely a thin layer upon the surface which, although obnoxious to the pleasure seeker who hates to wash his buggy, permits hauling at all seasons of the year. It would be impossible to construct any form of hard road or pavement which would not get muddy so long as the hard road covers only a portion of the roadway.

The stone roads dry up quickly in the spring time, and are not as dusty in the summer as the earth roads.

To determine some of the advantages derived from these particular stone roads, the writer interviewed a number of those living along the road. Most of the patrons seemed to be agreed upon the following: The average size of loads possible with stone roads is at least one third greater than with dirt roads. Stone roads permit a greater range of time in which to market crops, and permit advantage to be taken of changes in markets which could not be done without stone roads. The effect of wear on vehicles is not sufficient to produce any difference whether roads are of stone or dirt. Stone roads never freeze up as rough as earth roads. Stone roads are a little more severe on horses than dirt roads. The social advantages resulting from hard roads are appreciated and are themselves worth the cost of the roads.